CETHANA DAM

Tasmania

Submission for an

NATIONAL ENGINEERING LANDMARK

from

The Engineering Heritage Committee
Tasmania Division
The Institution of Engineers, Australia

September 2000

CETHANA DAM

CONTENTS

INTRODUCTION

Cethana is a 110m high concrete face rockfill dam (CFRD) on the Forth River in northern Tasmania. The purpose of the dam is to divert the combined flow of the Forth, Mersey and Wilmot Rivers to the underground Cethana Power Station for the production of electricity. The dam, spillway and power station were completed in 1971.

A construction village for the development was established at Gowrie Park (named after a nearby scout camp) beneath Mount Claude not far from the Cethana crossing of the Forth River. At its peak it had a population of 1,980 but, after construction was completed, the numbers have dwindled to a few dozen. The regional maintenance depot is still located there. Most of the prefabricated houses have been sold off and can now be seen scattered throughout Tasmania.

The Cethana Dam reservoir forms one of the key water storages that were created to form the Mersey-Forth Power Development in Northern Tasmania. The power scheme was investigated during the 1950s and early 1960s. The principal features of the scheme consist of diversions of the upper catchments of the Mersey and Wilmot rivers to the Forth River upstream of Cethana. Four power stations are used to generate electricity from the diverted flows. The combined flow of the three river systems is then used to generate additional electric power through a cascade of three dams and three power stations.

Cethana Dam is located in a narrow gorge with steep abutments, and it was planned to build a concrete arch dam. However closer examination of one abutment revealed a set of joints in the rock which might allow sliding movements under the thrust from the dam. Accordingly the arch proposal was abandoned and alternative dam types considered.

A rockfill embankment was the next choice. A major problem was the much wider base width of a rockfill dam, as the river diversion tunnel was already under construction. The upstream and downstream portals of the tunnel had been located to suit a thin arch dam, and only a rockfill dam with steep face slopes could be squeezed in between the portals. Rockfill being porous requires a sealing element which can be an internal earth core or a concrete slab on the upstream face. A rockfill dam with a central earth core has face slopes of 1 on 1.6, whereas a rockfill dam with a concrete face has face slopes of 1 on 1.3. For a 110m high dam, the difference in base width was 66m. There was therefore a strong incentive to choose a concrete face rockfill dam, in spite of the poor performance of all the high dams of this type overseas.

All the concrete face dams of this height in other countries had a bad record of high leakage due to the settlement of the rockfill when the reservoir was filled. These movements caused spalling of the concrete slabs at some joints and sometimes tearing of the waterstops in the joints. It was therefore very important to devise alternative design and construction methods which would reduce rockfill settlements and prevents damage to the face joints. These improvements were achieved at Cethana and received world-wide recognition over the next decade.

The investigation, design and construction of the dam was carried out by the Hydro-Electric Commission (now Corporation) with its own internal resources; some specialist reviews were provided by independent consultants for key aspects of the dam design and its implementation.

Main dimensions:

Dam type …..	Concrete face rockfill dam	
Height ….	110 m	
Length ….	213 m	
Volume of fill ….	Rockfill	1,365,000m^3
	Concrete	11,000m^3
Spillway type ….	Left bank fixed crest with downstream chute and flip bucket	
Spillway capacity	2 000m^3/sec at design flood level	
Lake volume ….	109 000ML	
Lake area …..	4.14km^2	

Commemorative Plaque Nomination Form

Date......***September 2000***

To:

Commemorative Plaque Sub-Committee
The Institution of Engineers, Australia
Engineering House
11 National Circuit
BARTON ACT 2000

From…***Tasmania Division***
Nominating Body

The following work is nominated for a ***National Engineering Landmark***

Name of work............................***CETHANA DAM***

Location, including address and map grid reference if a fixed work..............***On the Forth River, 35km south of Devonport. Grid ref***: ***E420 700 N 540 550, Map1:100 000 Forth 8115***

Owner.......................................***Hydro-Electric Corporation***

The owner has been advised of the nomination of the work and has given approval:

Copy of letter attached

Access to site.............................***By road from Devonport***

Future care and maintenance of the work.... ***Will be maintained by the Hydro-Electric Corporation as part of the Mersey-Forth Power Development.***

Name of sponsor........................***Engineering Heritage Committee, Tasmania Division***

For an NEL, is an information plaque required?..........***Yes***

…………………………………………
Chairperson of Nominating Committee

……………………………………………………
Chairperson of Division Heritage Committee

ADDITIONAL SUPPORTING INFORMATION

Name of work.. ***CETHANA DAM***

Year of construction or manufacture........ ***Completed 1971***

Period of operation.................................. ***Continuous since 1971***

Physical condition.................................... ***Excellent***

Engineering Heritage Significance:

Technological/scientific value .... ***Yes***

Historical value .... ***Yes***

Social value .... ***Yes***

Landscape or townscape value................. ***No***

Rarity... ***No***

Representativeness .... ***Yes***

Contribution to the nation or region......... ***Yes***

Contribution to engineering...................... ***Yes***

Persons associated with the work .... ***Yes***

Integrity.. ***Yes***

Authenticity... ***Yes***

Comparable works (a) in Australia...... ***Yes***

(b) overseas........... ***Yes***

Statement of significance, its location in the supporting doco…***Next page***

Citation (70 words is optimum)…..

NATIONAL ENGINEERING LANDMARK

CETHANA DAM

THIS 110M HIGH DAM SHOWED THE WORLD THAT HIGH CONCRETE FACED ROCKFILL DAMS COULD BE DESIGNED AND CONSTRUCTED WITH MINIMAL LEAKAGE, IN CONTRAST TO EXPERIENCE OVERSEAS. THE COMPACTION OF THE ROCKFILL IN LAYERS AND THE ELIMINATION OF HORIZONTAL JOINTS IN THE FACE SLABS CONTRIBUTED TO THIS EXCELLENT RESULT. WHEN COMPLETED IN 1971, IT WAS THE HIGHEST DAM OF THIS TYPE IN AUSTRALIA. MANY ENGINEERS FROM OTHER COUNTRIES INSPECTED THE DAM, AND ITS FEATURES WERE ADOPTED INTERNATIONALLY. (76 words)

Dedicated by the Institution of Engineers, Australia 2001

Attachments to submission (if any).................... ***See contents***

Proposed location of plaque (if not a site).......... ***Not applicable***

CETHANA DAM

STATEMENT OF SIGNIFICANCE

GENERAL

Cethana Dam has been nominated for listing on the Register of the National Estate. For that purpose a comprehensive Nomination was prepared in accordance with Australian Heritage Commission requirements. In that document the heritage significance of the dam was tested against nine National Estate criteria. Much of the information in the present submission has been extracted from that nomination.

TECHNOLOGICAL/SCIENTIFIC VALUE

In spite of their inherent safety one of the main problems with some of the early CFRD dams was excessive deformations under reservoir water loading. These movements caused the concrete face to crack and leakage could be substantial. Large deformations were the result of placing the rockfill by "dumping" in lifts several metres high leaving it in a loose state. At Cethana this problem was overcome by carefully placing the rockfill in thin layers and compacting it with a vibrating roller. This produced a much stiffer embankment and much smaller deformations.

Around the perimeter of the concrete face there is a concrete plinth on the foundation and a flexible joint between the plinth and the face slabs. A much improved plinth design was developed. Earlier plinths consisted of a concrete cut-off in a trench excavated into the rock by blasting. The Cethana plinth was built on top of the foundation rock to avoid blasting damage. The perimetric joint between the plinth and the face was also carefully re-designed to allow the relative movements to take place under hydraulic loading without disrupting the waterstops in the joint.

The concrete face was built by slipforming continuously from the plinth up to the dam crest without any intermediate construction joints, thus eliminating another source of leakage. The longest slabs took up to four days working around the clock.

After the reservoir was filled, the leakage from the dam was a very low 35 litres/second. Five technical papers on the design, construction, instrumentation and performance of Cethana Dam were presented at the 11th ICOLD Congress in 1973. The international community was skeptical that such an excellent result could be achieved but, over the ensuing years, their views changed and high concrete face rockfill dams took their place as a completely acceptable option, often the most economical choice for particular sites.

Many dam engineers from countries around the world came to see Cethana under construction, and later to see the completed structure and the evidence of its continued highly satisfactory behaviour. Its design features and construction methods have been copied in many dams subsequently constructed in other countries. In part its fame was spread by international consultant J Barry Cooke, a great advocate of this type of dam. He came regularly for consultations on Cethana, bringing news of other projects and taking away practices adopted by the HEC.

HISTORICAL VALUE

Cethana Dam was the first concrete face rockfill dam over 100m high in the world to exhibit minimal leakage.

SOCIAL VALUE

The social value of the dam arises from its use for the production of electricity for the Tasmanian community and industries, using a renewable resource.

LANDSCAPE VALUE

The dam fits neatly into a narrow gorge.

RARITY

Many dams of this type have been built, both in Australia and overseas. The first concrete face dam in Australia is Frome Dam, 17m high, constructed in northern Tasmania in 1908.

REPRESENTATIVENESS

Cethana Dam is representative of the high concrete-faced rockfill dams around the world which followed its construction. Like Cethana all of these dams used compacted rockfill and adopted some of the details pioneered at Cethana.

CONTRIBUTION TO NATION OR REGION

The construction of Cethana Dam was part of the development of Tasmania's water resources for power generation. It was built in response to the rising demand for electricity and helped to attract new industries to the state.

CONTRIBUTION TO ENGINEERING

Cethana Dam is a demonstration that Australian engineers are innovative and can be world leaders in their field of expertise.

PERSONS ASSOCIATED WITH THE WORK

The following HEC engineers were directly associated with the work:

John Wilkins	Asst Chief Civil Engineer Design (later Chief Civil Engineer)
Bill Mitchell	Engineer Design Group 3 (later Chief Civil Engineer)
Mike Fitzpatrick	Section Engineer Dams 2 (later Chief Civil Engineer and Asst General Manager Engineering)
Terry Liggins	Senior design engineer
Guy Ward	Project Manager Mersey Forth (later Chief Civil Engineer)
Geoff Bolt	Engineer-in-charge Cethana

INTEGRITY

The dam is in excellent condition. Like all large dams Cethana Dam is subject to regular surveillance and performance monitoring. Over the past 25 years the dam has performed very well. Rates of settlements and structural deformation have gradually declined. Regular leakage flow measurements have shown a marked reduction from approximately 35 litres/sec in 1971 to approximately 5 litres/sec in 1995. Thus far two detailed dam safety surveillance inspections have been carried out. Both surveillance reports indicate satisfactory behaviour.

AUTHENTICITY

The dam remains in its as-constructed condition. It is now known, however, that the capacity of its spillway needs to be increased, due to recent increases in the estimates of the spillway design flood.

COMPARABLE WORKS

(a) In Australia the first six concrete face rockfill dams constructed in Australia using compacted rockfill are set out below:

NAME	YEAR	HEIGHT	STATE
Running Creek	1966	20m	Vic
Risdon Brook	1968	36m	Tas
Pindari	1969	40m	NSW
Kangaroo Creek	1969	64m	SA
Wilmot	1970	34m	Tas
Cethana	1971	110m	Tas

It should be noted that Cethana is almost twice the height of the previous highest dam, and that the critical factor, settlement of the embankment, increases in proportion to the square of the height.

Following Cethana, 25 dams of this type have been built in Australia up until 1999. The highest is Reece Dam in Tasmania (122m, 1986).

(b) Overseas countless concrete face rockfill dams have been constructed. Up until 1996 the highest was the 187m high Aguamilpa Dam.

REFERENCES

1. ANCOLD 1990. *Register of Large Dams in Australia*, Australian National Committee on Large Dams, Hobart.
2. Cooke, J. Barry, 1997. "Concrete Face Rockfill Dams (CFRD)", *International Water Power & Dam Construction Yearbook*, pp 116-117.
3. Cole, B. A. (Ed) 2000. *Dam Technology in Australia 1850-1999.* Australian National Committee on Large Dams, Penrith.
4. Fitzpatrick, M. D., Cole, B.A., Kinstler, F.L., Knoop, B.P., 1985. "Design of Concrete Face Rockfill Dams", *Symposium on Concrete Face Rockfill Dams - Design, Construction, and Performance*, Proceedings of the Geotechnical Division of the American Society of Civil Engineers, Detroit, Michigan, USA, pp 410-434.
5. Fitzpatrick, M. D., Liggins, T.B., Barnett, R.H.W., 1982. "Ten Years Surveillance of Cethana Dam", *Trans 14th International Commission on Large Dams Congress*, Rio de Janeiro, Brazil, Volume I, Q52, R51, pp 847-866.
6. Fitzpatrick, M. D., Liggins, T.B., Lack, L.J., Knoop, B.P., 1973. "Instrumentation and Performance of Cethana Dam", *Trans 11th International Commission on Large Dams Congress*, Madrid, Spain, Volume III, Q42, R9, pp145-164.
7. Fitzpatrick, M.D, and Liggins, T.B., 1972. "Performance of Cethana Dam", *ANCOLD Bulletin* No. 36, pp 14-26, September.
8. Fitzpatrick, M.D., and Barnett, R.H.W., 1982. "Instrumenting Australia's Cethana Dam", *Water Power and Dam Construction*, Volume 34 No. 11, pp 26-30, November.
9. Griffiths, P.T.A., and Edmondson, R.F., 1973. "Diversion Closures by the HEC of Tasmania, in its Mersey-Forth and Gordon Power Developments", 1973. *Trans 11th International Commission on Large Dams Congress*, Madrid, Spain, Volume II, Q41, R47, pp 853-869.
10. Mitchell, W.R., 1973. "River Diversion Arrangements for the Cethana Power Scheme", 1973. *Trans 11th International Commission on Large Dams Congress,* Madrid, Spain, Volume II, Q41, R9, pp 145-158.
11. Szczepanowski, T.,1973. "Methods and Equipment for Slipforming Concrete Faces for Rockfill Dams", *Trans 11th International Commission on Large Dams Congress*, Madrid, Spain, Volume III, Q42, R4, pp 45-62.
12. Varty, A., Boyle, R.J., Pritchard, E.D., Gill, R.E., 1985. "Construction of Concrete Face Rockfill Dams", *Symposium on Concrete Face Rockfill Dams - Design, Construction, and Performance, Proceedings of the Geotechnical Division of the American Society of Civil Engineers*, Detroit, Michigan, USA, pp 435-458, October.
13. Wilkins, J.K., 1972. "A Revised Theory of Shear Strength of Rockfill", *Australian Geomechanics Journal*, Paper No. 3126, pp 55-59.
14. Wilkins, J.K., "Decked Rockfill Dams", 1968. *I E Aust Civil Engineering Transactions*, Volume CE10, pp 119-129 April, 1968. Republished in *Australian Geomechanics* Golden Jubilee of the International Society for Soil Mechanics and Foundation Engineering, Commemorative Volume, pp 112-122, 1985.
15. Wilkins, J.K., Mitchell, W.R., Fitzpatrick, M.D., Liggins, T.B., 1973. The Design of Cethana Concrete Face Rockfill Dam, *Trans 11th International Commission on Large Dams Congress*, Madrid, Spain, Volume III, Q42, R3, pp 25-44. (Also I E Aust *Annual Engineering Conference, Proceedings*, Perth, 1973)

ADDED April 2001:

16. Knoop,B P, "Cethana Dam. Nomination for Listing on the Register of the National Estate", May 1998.
17. Cethana Dam: Register of the National Estate: Database Number 101538.

Hydro
Hydro-Electric Corporation
ARBN - 072 377 158
GPO Box 355D
Hobart Tasmania 7001
4 Elizabeth Street
Hobart Tasmania 7000
Telephone (03) 6237 3400
Fax: (03) 6230 5823

Our Ref.
Your Ref.
Ask for

24 February 2000

Mr K C Drewitt
Chairman
Engineering Heritage Committee
The Institute of Engineers
2 Davey Street
Hobart Tas 7000

Dear Mr. Drewitt,

Thank you for your correspondence of 14 February 2000, advising of the eight dams which have recently been nominated for national heritage listing on the National Estate Register.

The Hydro is very pleased to approve the nominations and we look forward to hearing the outcome of the proposed public recognition awards.

With kind regards,

Yours sincerely,

Roger Gill
Generation Manager Generation

c.c. Andrew Pattle, Dam Safety Manager
Peter Grierson, Manager Power Schemes

CETHANA DAM

AUSTRALIA

TYPE: Concrete faced rockfill
HEIGHT: 110 m CREST LENGTH: 213 m
EMBANKMENT VOLUME: 1 380 000 m^3
STORAGE VOLUME: 108 million m^3
SPILLWAY CAPACITY: 2000 m^3/s
COMPLETED: 1971
OWNER: Hydro-Electric Commission of Tasmania

Cethana is the largest dam of the Mersey-Forth Development in the north of Tasmania. Built on the Forth River, it exploits the combined flow of four rivers of the area, employing a headrace tunnel which bypasses the right abutment, leading to the underground Cethana Power Station.

The embankment rockfill was placed in 0.9 m layers compacted with vibrating rollers, and it was completed up to crest level before the concrete face was begun. It has face slopes of 1:1.3 on both faces and the crest width is 9 m. The concrete face was slipformed in 12 m bays using heavy rail-mounted slipforms. Its normal thickness varies from 500 mm at the lowest point to 300 mm at the crest.

The spillway is a frontal-approach broad-crested weir with a concrete lined chute on the left abutment.

Services Provided

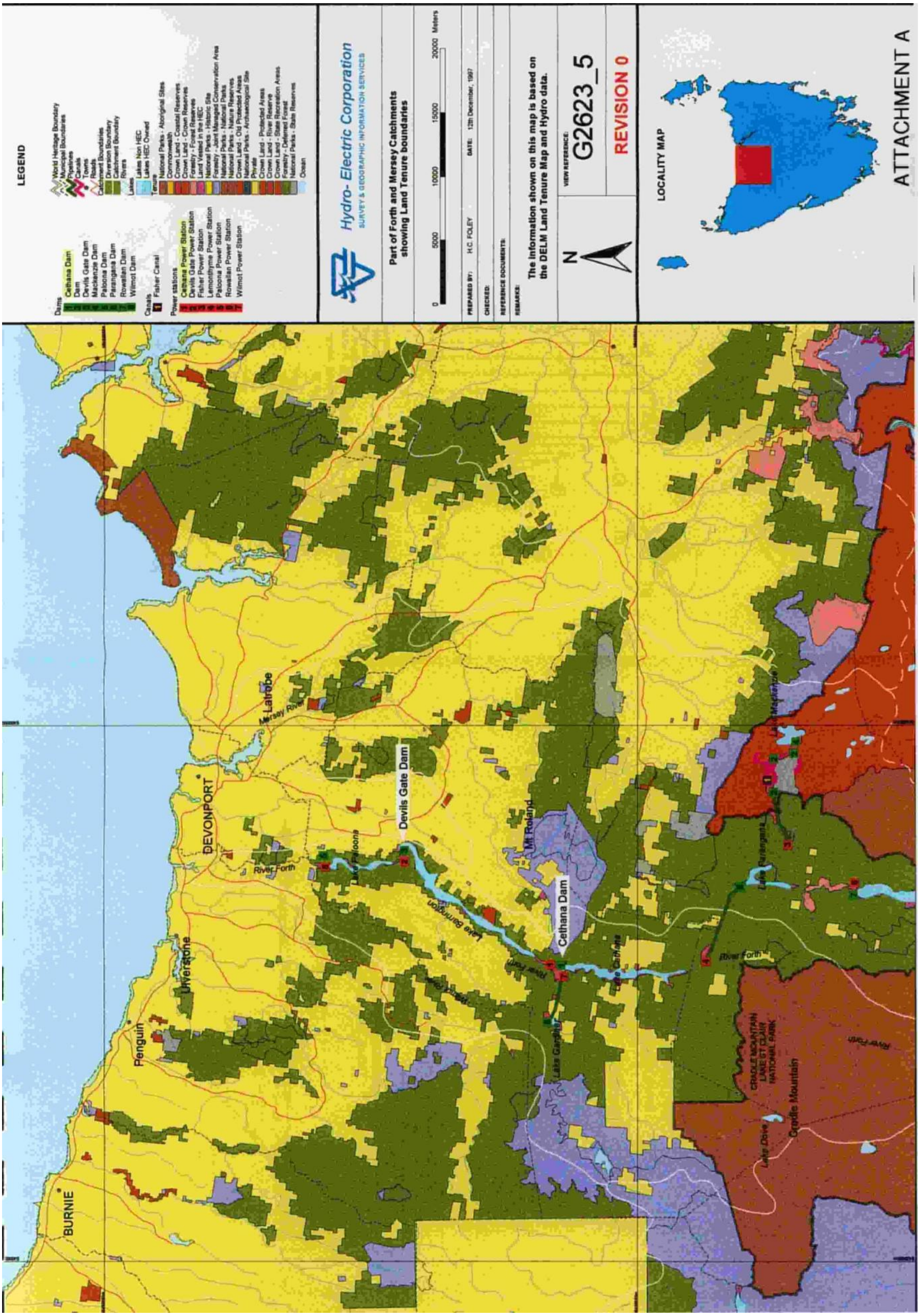
Feasibility study, investigations, detailed design, documentation, supervision of construction, operation and maintenance.

HEC

FIGURE 1

Photo 1 – Aerial view of Cethana Dam

Photo 2 – View of downstream face of Cethana Dam


LEGEND
Hydro-Electric Corporation
SURVEY & GEOGRAPHIC INFORMATION SERVICES
Part of Forth and Mersey Catchments showing Land Tenure boundaries
0
5000
10000
15000
20000 Meters
PREPARED BY: H.C. FOLEY
DATE: 12th December, 1997
N
The information shown on this map is based on the DELM Land Tenure Map and Hydro data.
G2623_5
REVISION 0
LOCALITY MAP
ATTACHMENT A
BURNIE
Penguin
Ulverstone
DEVONPORT
Latrobe
Mersey River
River Forth
Devils Gate Dam
Mt Roland
Cethana Dam
Lake Barrington
Lake Cethana
Lake Gairdner
Lake Mackenzie
Cradle Mountain
Lake Dove
CRADLE MOUNTAIN LAKE ST CLAIR NATIONAL PARK

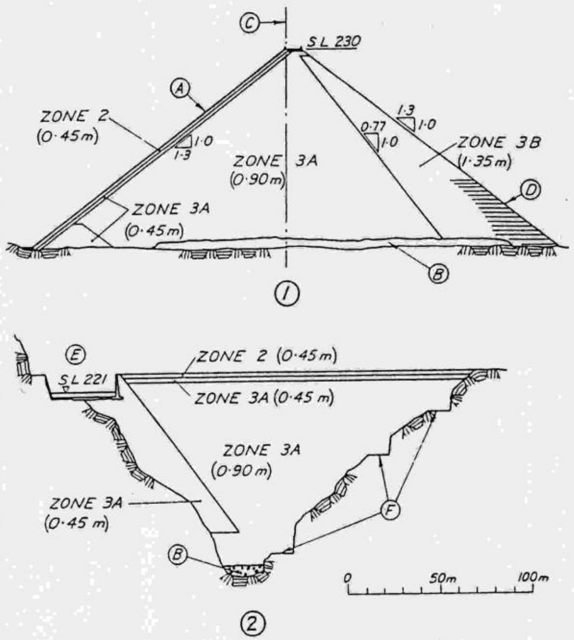


Fig. A

Dam sections.

(1) Section along river bed :
(A) Reinforced concrete membrane.
(B) River gravels.
(C) Dam axis.

(2) Section on dam axis :
(D) Mesh protection anchors.
(E) Spillway.
(F) Construction haul roads.

Figures in brackets are the layer thicknesses.

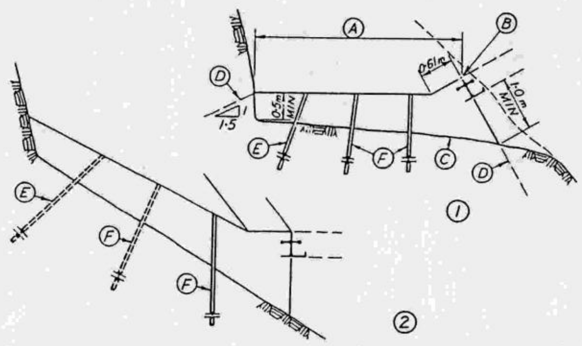


Fig. B

Sections through plinth.

(1) Section normal to plinth reference line.
(2) Section parallel to dam axis.
(A) Variable plinth width. Min. 3 m.
(B) Plinth reference line.
(C) Minimum excavation line.
(D) Plinth extension where rock is over excavated.
(E) Curtain grout hole.
(F) Consolidation grout hole.

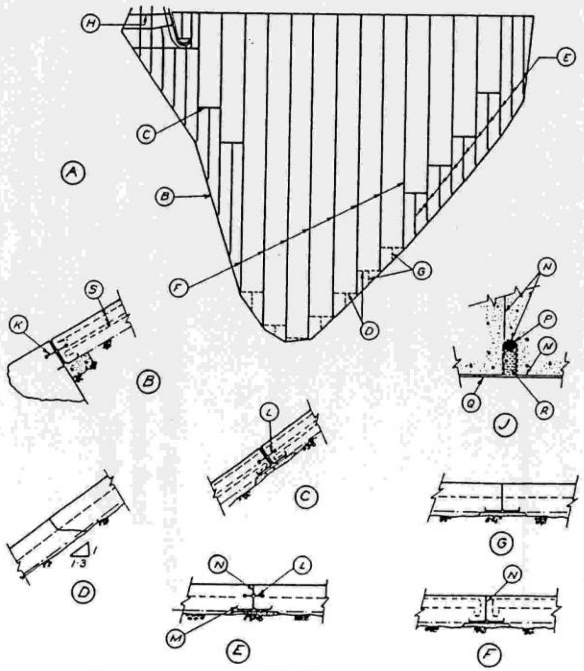


Fig. C

Joint layout and details.

(A) View normal to face.
(B) Perimetric joint.
(C) Horizontal contraction joint.
(D) Horizontal construction joint.
(E) Vertical contraction joint (Type 1).
(F) Vertical contraction joint (Type 2).
(G) Vertical construction joint.
(H) Spillway.
(J) Detail for copper waterstop.
(K), (L) 305 mm, 230 mm rubber waterstop.
(M) Copper waterstop.
(N) Surface painted with bitumen.
(P) 12 mm. dia. noeprene.
(Q) Bituminous felt strip.
(R) 16 mm × 32 mm closed cell polyethylene foam.
(S) Reinforcement.

FIGURE 2

FIGURE 2

AUSTRALIAN HERITAGE COMMISSION

Register of the National Estate Database

Cethana Dam, Gowrie Park TAS

Class: Historic
Legal Status: Indicative Place

Database Number: 101538
File Number: 6/02/034/0013

Nominator's Statement of Significance : Cethana Dam's claim for National Estate registration is primarily based on its technical significance as one of the first successful high concrete faced rockfill dam (CFRD) designs. Assessments of its significance under the Australian Heritage Commission's criteria D2, F1 and H1 are presented below.

CRITERION D2: Importance in demonstrating the principal characteristics of classes of human activities in the Australian environment (including way of life, land-use, function, design or technique).

The dam is a fine example of its type.

The Cethana Dam is a prominent example of the Concrete Face Rockfill Dam (CFRD) type. This dam demonstrates the principal characteristics of the CFRD design of the modern era. Cethana is an example of innovative engineering as explained in criterion F1. The dam design solution that was adopted, after the original arch dam design had been abandoned due to serious foundation problems, was well executed and attracted an extraordinary amount of interest both within Australia and overseas. It was instrumental in changing the entrenched views of dam designers that CFRDs were safe but "leaky" structures. This dam showed itself to be both safe and virtually watertight. When it was conceived it was the largest CFRD structure in Australia. Currently it is still the second highest CFRD in Australia, after the Reece Dam. It is the tenth highest dam in Australia. In Australian and world dam engineering, Cethana and its design details have become a landmark of the concrete faced rockfill dam type. The Cethana Dam is frequently quoted in technical papers and reviews of CFRDs, for instance in the recent overview of this type of dam by J. Barry Cooke in the International Water Power & Dam Construction Yearbook 1997 (copy attached).

CRITERION F1: Importance for its technical, creative, design or artistic excellence, innovation, or achievement.

This dam is a typical example of innovation in design..

The design solution that was adopted for Cethana Dam was both innovative and economic and was

a major achievement in the execution of large concrete face rockfill dams (CFRDs) at that time.

Cethana Dam is the key storage and control feature of the Mersey-Forth Power Development and it also has the largest installed generating capacity of the seven power stations in the whole scheme.

At the investigation stage of the project a 107m high double curvature arch dam was planned for the Cethana site. The Forth River valley is 'U' shaped with sound rock exposures on both sides that were considered suitable for a concrete arch dam. The proposed arch dam design is described in detail in the investigation reports published at the time. During the detailed site investigation phase, an adverse jointing system was discovered on the left abutment. The remedial work that was required to stabilise this abutment was expected to be expensive and the long-term effectiveness of a post-tensioned foundation structure could not be guaranteed. When these foundation deficiencies were found the river diversion tunnel was nearing completion and a new design arrangement had to be developed quickly to keep the project construction programme on schedule. Alternative designs that were considered included a concrete gravity dam and a clay core rockfill dam. The cost of a concrete gravity structure was expected to be more expensive than the original arch dam and was rejected on that basis. The problem with a clay core rockfill dam embankment was that the upstream toe would extend well beyond the intake for the diversion tunnel portal that was already in place.

It was at this stage that the option of designing a concrete face rockfill dam (CFRD) was seriously considered. Although the CFRD design was not new - it had been used quite extensively for small to medium size water storages, especially for mining developments, since the late 1800s - it had rarely been used for larger dams. The recent examples of large CFRD designs that had been built included the 110m high Paradela Dam [1958] in Portugal and the 150m high New Exchequer Dam [1966] in the USA. Both dams had experienced severe leakage problems and required extensive remedial work. At the time two CFRD designs were in progress in Australia, i.e. the 60m high dam Kangaroo Creek Dam in South Australia, and the 45m high dam Pindari Dam in NSW. A CFRD with a height in excess of 100m had not been built in Australia.

The HEC did have some experience with CFRD designs and several small structures of this type had been constructed in Tasmania. The key design feature that was being investigated at the time was the use of roller compaction of the rockfill. For most CFRDs the rockfill had been placed by dumping it in thick layers which left it in a loose condition. For the new large CFRDs it was now proposed to place the rockfill in layers about one metre thick and to compact these layers with mechanical vibrating rollers. The main objectives of roller compaction were: to increase the modulus of deformation of the rockfill; to place the fill near the upstream face to closer tolerances and to control the deformation of the upstream face membrane especially along its contact with the foundation. A considerable amount of investigation and testing was carried out for the design of Cethana. At the same time new construction methods were being developed to improve, a) the placing of the rockfill in several specific zones, and b) the placing the upstream face concrete with mechanised slip-form systems. An extensive embankment instrumentation system was also developed to monitor the structural behaviour of the dam and its upstream face during its construction and subsequent operating phases.

Storage filling of the Cethana Dam commenced in 1971. The dam has continued to perform "better", that is, with less deformation than was originally anticipated. Regular structural monitoring over a 25 year period has confirmed that the embankment deformations are minimal for a structure of this size, and are nearly an order lower than the examples of CFRDs using dumped rockfill.

The design and construction of Cethana Dam created a considerable amount of interest within the

dam building community both within Australia and overseas. Numerous national and international experts inspected the Cethana Dam site. A number of technical papers were written about design, construction and performance aspects of the dam. Twenty-five years later some of these papers are still being referred to in international technical publications.

The development of the CFRD design for Cethana Dam proved to be very successful. The Cethana Dam was one of the first large CFRDs that demonstrated that this type of structure could be built successfully to heights in excess of 100m.

Although a number of design refinements have been introduced over past 25 years the basic CFRD concepts as developed for the Cethana CFRD continue to be used in many countries, particularly in developing countries. The latest CFRD designs that are currently being planned include dam embankments with heights greater than 200m (see reference 34, a copy of which is attached to this nomination).

CRITERION H1: Importance for close associations with individuals whose activities have been significant within the history of the nation, state or region.

An individual whose activities have been significant within the state.

John Kirby Wilkins was a prominent engineer whose activities have been significant within the state and who was closely associated with the design and construction of the Cethana concrete face rockfill dam (CFRD). The Hydro-Electric Commission attracted a substantial number of outstanding engineers and associated professionals from within Australia and overseas. The resulting mix of engineering experience was of great benefit to the organisation. Management fostered a progressive approach to investigation design and construction. Interaction with national and international learned societies was encouraged. Innovative design solutions were considered and invariably adopted.

Description : The Place

Cethana is an 110m high concrete face rockfill dam (CFRD) on the Forth River in Tasmania. The purpose of the dam is to divert the combined flow from the Forth, Mersey and Wilmot Rivers to the underground Cethana Power Station for the production of electricity. The dam, spillway and power station were completed in 1971.

The name 'Cethana' means 'hair' in the local Aboriginal dialect. The PAR.RIT.TOR.HE people occupied the country near the Gog Range to the east of the Forth River.

The River Forth rises on the glacial cirque between Mount Pelion West (1554m) and Mount Achilles (1363m) in the centre of the Cradle Mountain - Lake St Clair National Park. In its approximately 70km northerly route to Bass Strait, its tributaries also drain Cradle Mountain, Barn Bluff and Mount Roland.

The surface geology of the upper part of the catchment area consists of predominantly Precambrian metamorphic rocks. At the Cethana dam site a narrow band of Ordivician siliceous conglomerates, shallow-water quartzose sandstones and siltstones crosses the river valley at approximately right angles. There are outcrops of reddish quartzites that have resisted erosion. The site had obvious attractions for the construction of an arch dam.

The Forth River has some distinctive features. For the first 10km it flows in an alpine environment through the Cradle Mountain - Lake St Clair National Park. Then it follows an approximately one

kilometre wide and 300m deep U-shaped glacial valley that subsequently changes into a V-shaped gorge. Over the last 15km the valley widens out into broad flood plains.

For most of its length the sides of the valley are covered in a thick high forest in which the predominant species is Eucalyptus obliqua (wet forest). There are also exposures bare rock at several places.

Historical Summary

European settlement and development of the North West Coast region of Tasmania lagged well behind that of the eastern half of the island.

Coastal surveys in 1823 and 1824 found that forests reached almost to the water's edge of Bass Strait while the undergrowth made penetration of the interior a slow and arduous business. These early surveys located the mouths of the major rivers. They were originally named the First, Second, Third and Fourth Western Rivers with reference to the Tamar River. The River 'Forth' was given the name 'Third Western River' but it was actually the fourth river, the nearby Don River having been missed out of the sequence. This was probably how the name Forth, i.e., 'fourth', river originated 1.

In 1823 surveyor John Roland, attempting to find a route westward from the Deloraine district, climbed Mount Roland (named after him) and looked out on a vast forest to the north and west as well as the deeply incised tree-filled valley of the River Forth. The party was unable to penetrate further west and retraced its steps back to Deloraine 2.

The forest stretched a distance of 30-40km inland from the coast (Bass Strait) and extended from just west of Deloraine to Circular Head (present day Stanley).

In 1826 the London based Van Diemen's Land Company (VDL), which had been given a grant of 250,000 acres (1012km2), established their headquarters between present day settlements of Devonport and Port Sorell. Their surveyors reported that the forest was a barren wilderness little knowing that the ground comprised some of the most fertile soil in the colony, namely the rich dark-red basalt loam for which the North West Coast is now famous.

The VDL Company regarded the clearing of the forest as impractical and, being prevented by Lt Governor Arthur from further development around Port Sorell, took up their leases in the more open country to the south of the forest and in the Circular Head district further west.

On a map published in 1828 by the VDL Company's surveyor, Henry Hellyer 4, the approximate course of the River Forth (under that name) is shown from the coast to a point 17km south of Mount Roland. Also shown are features called the 'Forth Gateway' at the present site of the Cethana Dam, opposite Mount Claude and the VDL Company's cart track between Deloraine and the company's grants at Middlesex Plains and Hampshire Hills. The track fords the River Forth just below the present Cradle Mountain - Lake St Clair National Park boundary, nearly 15km south of the Cethana Dam site.

George Augustus Robinson passed through the upper Forth area in the winter of 1834 with a party of Aborigines that included Trugernanna and her husband Wooraddy. They camped at the Iris River near the site of Wilmot Dam, then three days later the party crossed the Forth River at the VDL Company's track 11.

It was not until the Australia-wide system of 'ring barking' was invented around 1841 by James

Fenton, on his farm near the River Forth heads, that the clearing of these forests became economically feasible 3. Forest clearing gradually extended through most of the basalt loam country. Several deeply incised river valleys (of which the Forth was one) divided the original forest. As these rivers had cut into the less fertile rocky strata below the basalt plains, the forest in the steep valleys was preserved. The northern river valleys have remained barriers to east west communications to the present day.

Fenton joined the Victorian gold rush in February 1852. While wandering around the tent city of Melbourne he realised that here was a great market for timber and thought of the Devon forests and the 80,000 split palings he had stored at Forth. He thus resolved to return home which he reached after being shipwrecked on King Island. In all he sent 500,000 palings from the Forth and the Leven River valleys to Melbourne while prices where high.

Sheffield was the first inland town. Located 23km south of Devonport and 17km northeast of the Cethana Dam site, it was laid out in 1859 and became the administrative centre for the Kentish local government area.

In the early 1860s a resident of Forth, James (Philosopher) Smith, prospector and later discoverer of the Mount Bischoff tin deposits at Waratah, came across a forest of King William (King Billy) pines in the Dove River valley, a tributary of the Forth, not far from Cradle Mountain. He felled a number of pines and floated them down the rivr 7.

A few years later, in 1868, Wm Crosby and A Raymond, in search of further forests of King William pine, made a 40km voyage up the Forth River from the coast to the VDL Company's track crossing 8. This was no mean feat as the river beyond the first kilometres was entirely unreported apart from the 'Forth Gateway' at the present Cethana dam site. The river was found to be a succession of rapids with intervening stretches of still water. Great difficulty was experienced in hauling their flat bottomed boat over the rapids. After nine days they reached the Forth Gateway, a jumble of 'huge' boulders. Here they abandoned their boat and after another three days of scrambling over fallen timber reached the VDL Company's track. In their account no mention was made of the more imposing gorge at the Devils Gate dam site, probably because it was less of a problem to their progress, the concentrated flow of water having removed most of the boulders.

Crosby and Raymond did not find any pine forests but the following year organised an overland expedition to the Dove River valley. About 200 King William pine trees up to 1.5m in diameter were felled and floated down the Dove and Forth Rivers. This was a haphazard affair, some floating down to the Forth heads and being recovered, others becoming stranded and still others being washed out to sea and never seen again.

Around 1884 the township of Sheffield was linked with Wilmot, a hamlet of on the other side of the Forth River gorge, ten kilometres downstream of Cethana. The link consisted of a rough track, later upgraded to a road, and a crossing known as Luttrell's Bridge.

Investigations into the power potential of the Forth and Mersey Rivers commenced in the 1950s. In 1963 the Mersey-Forth-Wilmot Power Development was approved by the Tasmanian Parliament as part of the Government's policy of hydro-industrialisation. The development consists of seven power schemes (i.e. dam, power station etc.) with a total installed capacity of 308MW. The power development provided jobs for the Tasmania population not only in the design and construction of the power schemes but also in the industries that utilised its electric energy.

A construction village for the development was established at Gowrie Park (named after a nearby scout camp) beneath Mount Claude not far from the Cethana crossing of the Forth. At its peak it had a population of 1,980 but after construction was completed, the numbers have dwindled to a

few dozen. The regional maintenance depot is still located there. Most of the prefabricated houses have been sold off and can now be seen scattered throughout Tasmania.

In 1971 Luttrell's Bridge was submerged by the Devils Gate Dam reservoir, Lake Barrington. This river crossing was replaced with a new bridge just downstream of the Cethana Dam. A modern road now forms the main route to Cradle Mountain and also provides access to the Cethana and Wilmot Power Schemes.

Historical Biographies

Henry Hellyer (1790-1832)

The Cethana Dam reservoir forms one of the key water storages that were created to form the Mersey-Forth Power Development in Northern Tasmania. The power scheme was investigated during the 1950s and early 1960s. The principal features of the scheme consist of diversions of the upper catchments of the Mersey and Wilmot rivers to the Forth River upstream of Cethana. Four power stations are used to generate electricity from the diverted flows. The combined flow of the three river systems is then used to generate additional electric power through a cascade of three dams and three power stations.

The Cethana Dam was constructed during the years 1967 to 1971. During the construction phase serious foundation deficiencies were encountered that required a complete change of design from a planned concrete arch dam to a rockfill embankment with a concrete face.

What is a concrete face rockfill dam? In simple terms it consists of:
.a compacted rockfill embankment,
.a watertight reinforced concrete upstream face supported by the rockfill embankment, and
.a concrete plinth that provides a waterproof connection between the concrete face and the foundation rock.

This design concept was first developed during the 1800s by miners in the United States. They required pressurised water for sluicing operations. Their rockfill dams were simply constructed by dumping gravel or boulders in the form of a rough bank across a creek. The waterproof upstream face was made of timber, steel or concrete. These early faced rockfill dams were cheap to construct and were only expected to last for as long as the mining operations were profitable. If a dam of this type was washed away, due to overtopping, it was relatively easy to replace.

The first CFRD to be constructed in Australia was the Frome Dam in northeastern Tasmania. This small dam was built in 1906 by the Pioneer Mining Company for its tin sluicing operations and electricity requirements.

During the 1940s and 1950s there was a renewed interest in the construction of concrete face rockfill dams. With the developments in modern earth-moving equipment, the construction of fill dams became more attractive, although these embankments were mainly of the impervious clay core type. One disadvantage of clay cores is that the clay has to be placed under carefully controlled conditions so that the optimum moisture content can be maintained. This control is often difficult to achieve in a wet climate. On the other hand, CFRDs can be constructed in all weather conditions, and the volume of the rockfill embankment for a CFRD is considerably less, due to the steeper face slopes that could be adopted.

In spite of their inherent safety one of the main problems with some of the early CFRD dams was excessive deformations under reservoir water loading. These movements caused the concrete face

to crack and leakage could be substantial. Large deformations were the result of placing the rockfill by 'dumping' in lifts several metres high leaving it in a loose state. At Cethana this problem was overcome by carefully placing the rockfill in thin layers and compacting it with a vibrating roller. This produced a much stiffer embankment and much smaller deformations. A much improved plinth design was also developed. It was built on top of the foundation rock rather than in a trench, thus decreasing blasting damage of the foundation rock. The junction between the plinth and the face was also carefully re-designed to sustain the relative movements that take place under hydraulic loading.

As the material characteristics of compacted fill materials became better understood, the construction of high CFRDs became feasible. With the introduction of numerous design innovations CFRDs have become one of the most economical types of dam designs, adaptable to a wide range of foundation conditions. Cethana can truly be considered the successful precursor of the modern CFRD design.

Lake Cethana is a vital part of the Mersey - Forth Power Development. Its catchment contributes about 42 percent of the flow through the power station and about 27 percent of the average power generated by the whole scheme. Much of the power generated can be attributed to the height of the dam.

Both the Cethana Dam and the power scheme have performed in accordance with the design criteria that were adopted. An analysis of the energy production statistics for the power scheme indicates that the Cethana scheme has produced on average 410GWh of electricity per year which is slightly less than the estimated long term average, but over the last six years Cethana has generated more energy than the long term average.

Like all large dams the Cethana Dam is subject to regular surveillance and performance monitoring. Over the past 25 years the dam has performed very well. Rates of settlements and structural deformation have gradually declined. Regular leakage flow measurements have shown a marked reduction from approximately 35 litres/sec in 1971 to approximately 5 litres/sec in 1995. Thus far two detailed dam safety surveillance inspections have been carried out. Both surveillance reports indicate satisfactory behaviour.

The dam has also been reviewed in respect of its design flood capacity and its resistance to shaking by earthquakes. The review of the dam's flood capacity shows that the present spillway arrangement is no longer adequate. Since the dam was designed in the late 1960s improved methods of flood analysis have resulted in a substantially greater design flood which is typical for many older dams. Measures are planned to reduce the risks associated with the inadequate spillway capacity. Tasmania is generally considered to be a region of low seismicity, the dam's resistance to earthquakes is considered to be satisfactory.

The investigation, design and construction of the dam was carried out by the Hydro-Electric Commission (now Corporation) with its own internal resources; some specialist reviews were provided by independent consultants for key aspects of the dam design and its implementation.

Condition and Integrity : Like all large dams the Cethana Dam is subject to regular surveillance and performance monitoring. Over the past 25 years the dam has performed very well. Rates of settlements and structural deformation have gradually declined. Regular leakage flow measurements have shown a marked reduction from approximately 35 litres/sec in 1971 to approximately 5 litres/sec in 1995. Thus far two detailed dam safety surveillance inspections have been carried out. Both surveillance reports indicate satisfactory behaviour.

The dam has also been reviewed in respect of its design flood capacity and its resistance to shaking

by earthquakes. The review of the dam's flood capacity shows that the present spillway arrangement is no longer adequate. Since the dam was designed in the late 1960s improved methods of flood analysis have resulted in a substantially greater design flood which is typical for many older dams. Measures are planned to reduce the risks associated with the inadequate spillway capacity. Tasmania is generally considered to be a region of low seismicity, the dam's resistance to earthquakes is considered to be satisfactory.

Location : The dam is located on the Forth River in Northern Tasmania approximately 35km south south west of Devonport.
The boundary of the area (for National Estate listing) of the dam and its impounded Lake Cethana should be that area encompassed by the normal full supply water level (FSL) of the lake plus the area of the dam including appurtenant structures.

The Register of the National Estate has been compiled since 1976. The Commission is in the process of developing and/or upgrading official statements of significance for places listed prior to 1991.

Report produced : 8/4/2001
RNEDB URL : http://www.environment.gov.au/heritage/register/easydatabase/database.html

[RNE search | AHC Home | Disclaimer | ©]